

Evaluation of Downstream Migrant Chinook Production in Two Lake Washington Tributaries, Cedar River and Bear Creek

Dave Seiler

Science Division

Washington Department of Fish and Wildlife, Olympia WA 98501-1091

The Washington Department of Fish and Wildlife has assessed sockeye fry production through downstream- migrant trapping in the Cedar River since 1992. This nightly trapping operation, which begins in January and continues through at least May each year, also captures juvenile chinook. Catches vary widely between nights and years but overall describe a substantial early emigration of chinook fry from the Cedar River (**Figure 1**).

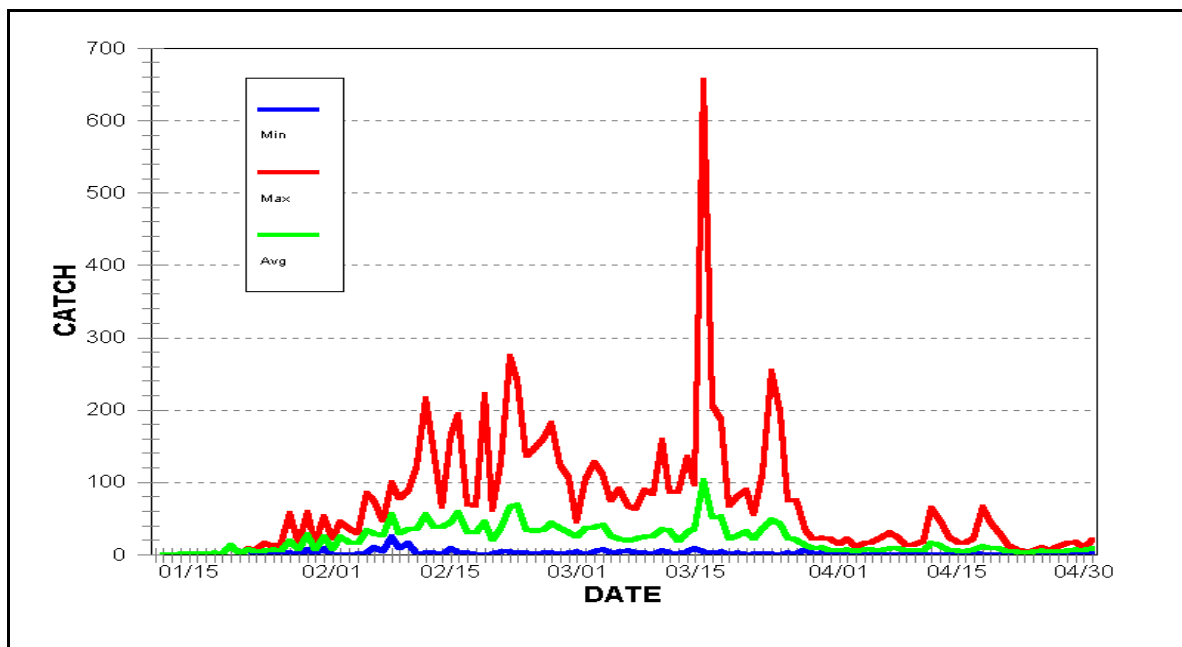


Figure 1. Range of nightly chinook fry catches in the Cedar River sockeye fry trap, 1992-1998.

Because we designed, located and operated this gear to capture sockeye fry, capture rates on larger migrants, including chinook, are unknown. For the early portion of the migration, before chinook fry increase in size, we approximate their migration using capture rates we estimate with marked sockeye fry. To quantify the entire chinook migration, beginning in 1999, with funding from King County, we also installed and operated screw traps in the lower Cedar River and in Bear Creek. Due to their size, design and placement in locations with relatively high water velocity, these traps capture emigrants with little or no size selectivity. Over the trapping season, capture rates were estimated through release and recapture of marked chinook smolts.

This presentation describes and compares the biological attributes of juvenile chinook produced from the Cedar River and Bear Creek, in 1999 and 2000.

Results

In both years, the majority of the total migration occurred before mid April followed by a smaller migration which began in May and continued through June (**Figure 2**).

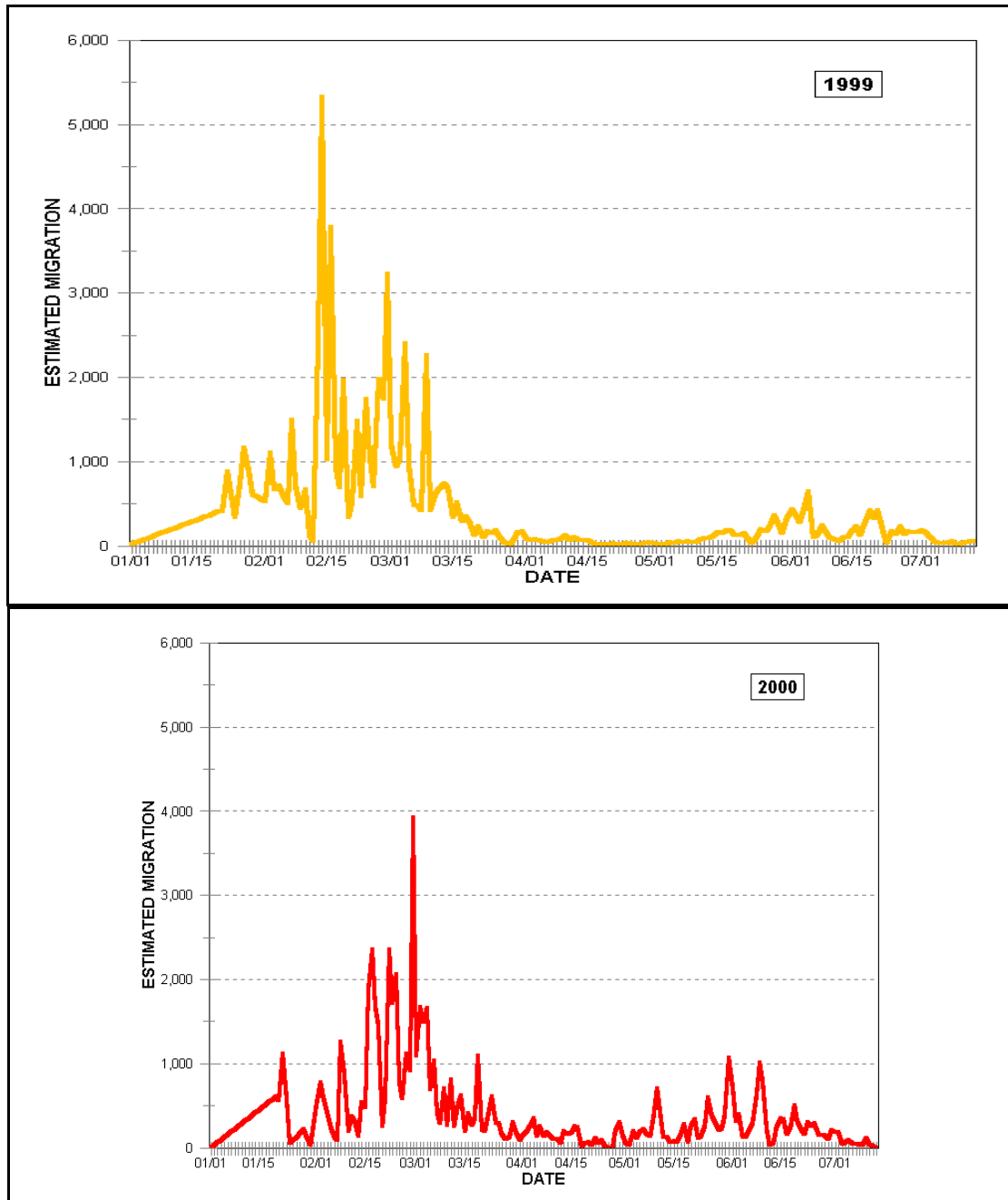


Figure 2 Production and timing of age zero chinook from the Cedar River in 1999 and 2000.

Bear Creek chinook also exhibited an early and late migration, but in contrast to the Cedar, the majority

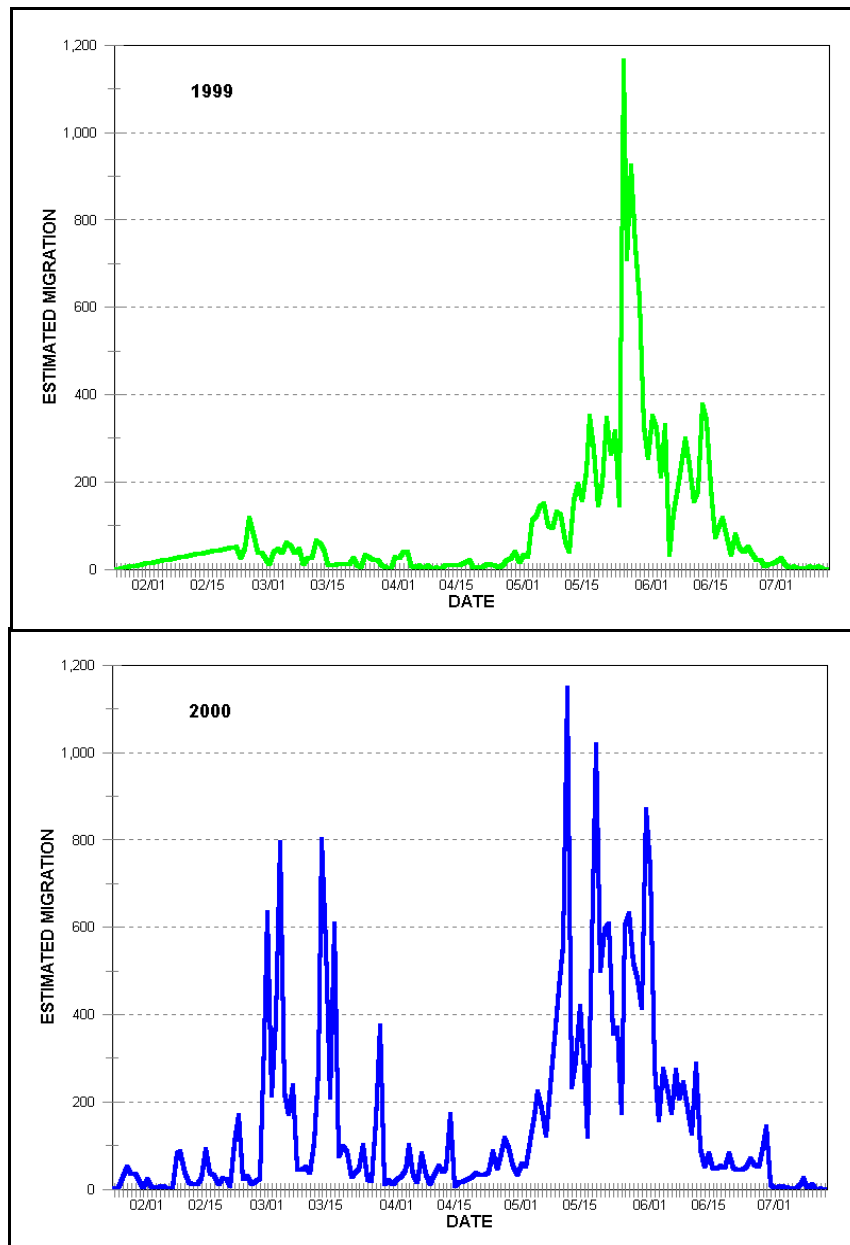


Figure 3 Production and timing of zero age chinook from Bear Creek in 1999 and 2000.

of the production emigrated after mid-April (**Figure 3**). Between the two years there was also a notable difference. Nearly 90% of the production in 1999 occurred after mid-April while in 2000, two thirds of the migration occurred after mid-April.

Mean weekly size of Cedar River chinook remained around 40 mm (fork length) until week 16 (mid-April) (**Figure 4**). From mid-April through July, weekly mean size increased steadily in both years to exceed 100 mm in late-July.

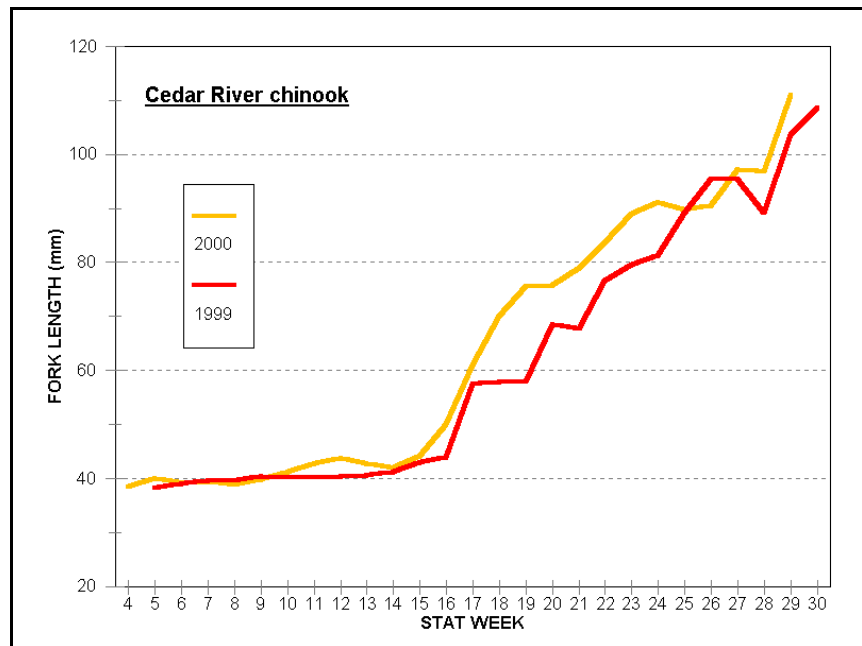


Figure 4 Size at time, Cedar River juvenile chinook in 1999 and 2000.

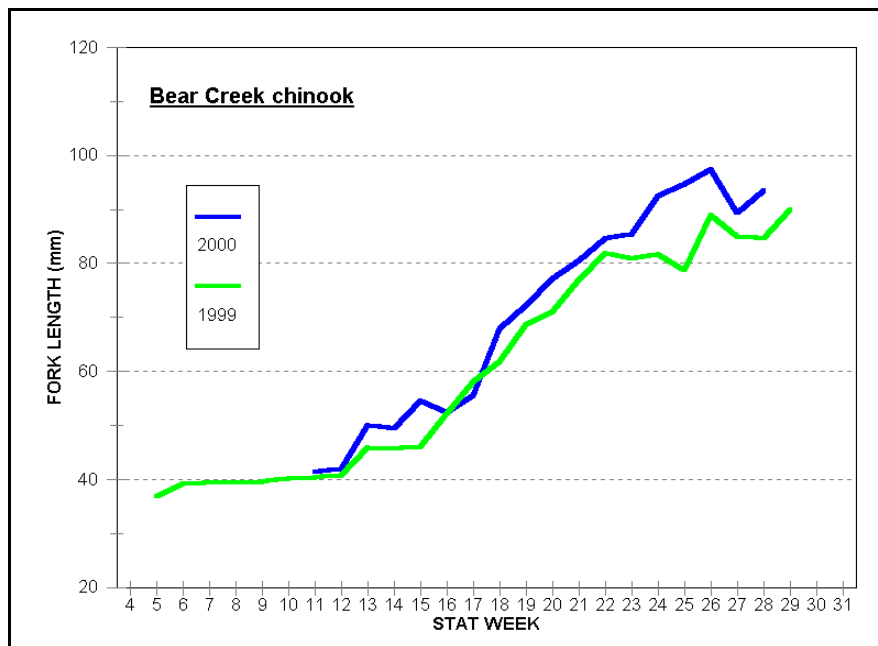


Figure 5 Size at time, Bear Creek juvenile chinook in 1999 and 2000.

Mean size of chinook migrants from Bear Creek began to increase around week 13, somewhat earlier than in the Cedar River (**Figure 5**). Aside from this earlier start, size at time appears similar for both populations but because the Bear Creek chinook migration ended in early July the maximum size is lower than that observed in the Cedar River. These differences in growth and timing probably reflect the temperature and flow differences between the two systems.

BEAR CREEK

Smolt Year (i)	Estimated Migration			Percent Migration		Est Female Esc (i-1)	Production/Female		Survival Ratios		
	thru Apr 15 ^a	Apr 16-Jul 13	Total	thru Apr 15	Apr 16-Jul 13		Fry (thru Apr 15)	Smolts (Apr 16-Jul 13)	Fry/PED	Smolts/PED	Total
1999	2,092	13,205	15,297	14%	86%	160	13	83	0.3%	2.1%	2.4%
2000	8,631	17,776	26,407	33%	67%	293	29	61	0.7%	1.5%	2.3%

^a The 1999 estimate includes 774 additional chinook, estimated by extrapolation. Trapping in 1999 began on February 23. We estimated the migration during the 30 days between January 24 through February 22 using the average migration/day (25.8 chinook) from the period trapped (February 23 through April 15).

^b We assumed that females comprised 40% of the estimated escapements in 1998 and 1999, 401 and 733, respectively (Steve Foley, WDFW pers comm). We also assumed an average fecundity of 4,000 eggs.

CEDAR RIVER

Smolt Year (i)	Estimated Migration			Percent Migration		Est Female Esc (i-1)	Production/Female		Survival Ratios		
	thru Apr 15 ^a	Apr 16-Jul 13	Total	thru Apr 15	Apr 16-Jul 13		Fry (thru Apr 15)	Smolts (Apr 16-Jul 13)	Fry/PED	Smolts / PED	Total
1999	66,143	11,653	77,796	85%	15%	173	382	67	9.6%	1.7%	11.2%
2000	57,219	19,549	76,768	75%	25%	96	596	204	14.9%	5.1%	20.0%

^a Migration through April 15 is based on fry trap catches. Migration after this date is based on screw trap catch.

^b The 1999 estimate includes 5,755 additional chinook, estimated by extrapolation from January 23 back to January 1. The 2000 estimate includes 5,780 additional chinook, estimated by extrapolation from January 20 back to January 1.

Table 1 Estimated production, timing and survival to fry and smolt stages for chinook migrating from the Cedar River and Bear Creek in 1999 and 2000.

In the table above, I refer to the two migrations as “fry” and “smolts” to describe the early and later movements evident in **Figures 2 and 3**. Relating the estimates of fry to estimated numbers of female parent spawners yields ratios that range from low values of 13 and 29 in Bear Creek to the relatively high values of 382 and 596 in the Cedar River for the two broods measured. Smolt to female ratios show less variation between the two systems ranging from a low of 61 in Bear Creek to 204 in the Cedar in year 2000. Relating the estimates of fry and smolts to estimates of potential eggs deposition (PED) yields survival ratios to each life stage. The total of these ratios represent egg-to-migrant survival. In Bear Creek, fry emigration accounted for less than one percent of the eggs deposited in both years while smolts accounted for around 2%. In the Cedar, 10-15% of the eggs deposited migrated as fry, while the proportion migrating as smolts varied threefold, from 1.7% to 5.1% in 1999 and 2000. The veracity of these estimates rely not only on our estimates of migrants but also on the estimates of adult spawners. In addition, to transform estimates of escapement into PED, we assumed that females comprised 40% of the spawners and that each one deposited an average of 4,000 eggs.

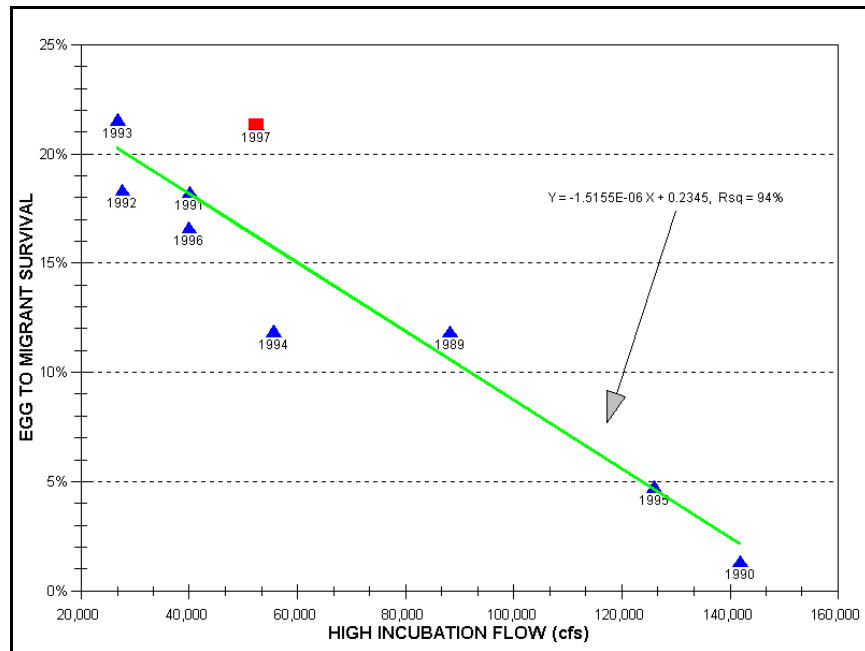


Figure 6 Egg to migrant survival of Skagit River wild chinook as a function of peak one day discharge, over ten brood years, 1989 to 1998.

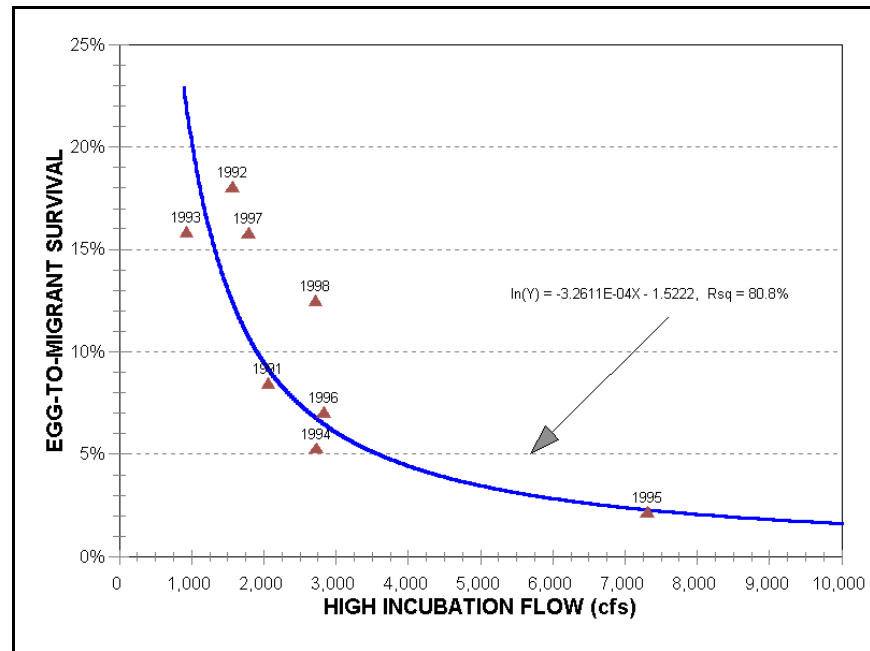


Figure 7 Egg to migrant fry survival of Cedar River sockeye as a function of peak discharge during egg incubation, brood years 1991 to 1998.

Figures 6 & 7 are examples of populations that we have assessed over a number of years and as a result, have identified severity of flow during egg incubation as the primary factor regulating inter-annual variation in freshwater survival rates. Flow has such a dominant effect on the freshwater production of anadromous fish that it generally drives survival-to-downstream migration, and thereby often explains a significant portion of the fluctuation in juvenile population dynamics. When such effects are severe enough, and not subsequently overridden by other variables such as marine survival, their impact is also apparent in adult recruit rates.

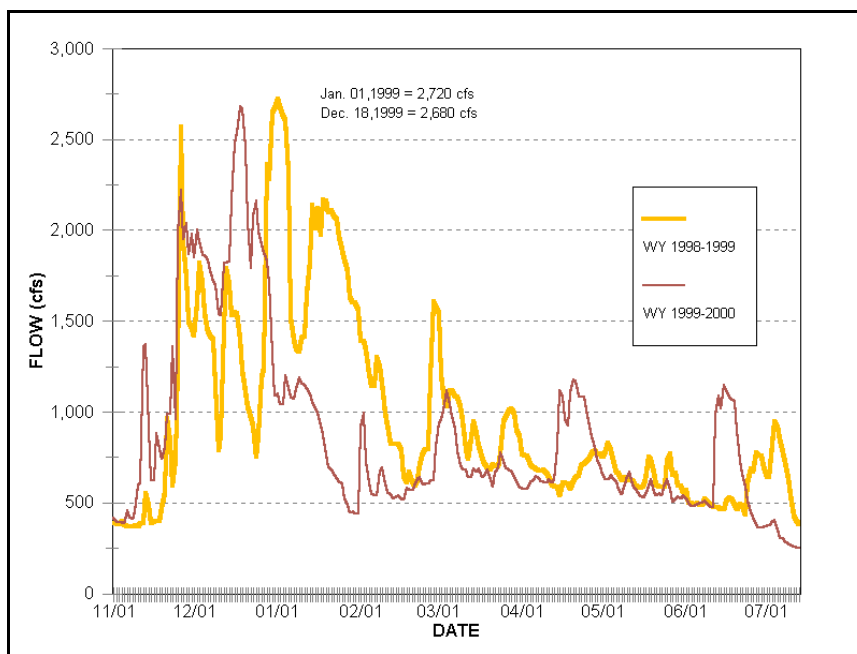


Figure 8 Comparison of daily mean flow (November through July), by water year, in the Cedar River at Renton.

While flow levels and variations are certainly important to the reproductive success of chinook spawning in the Cedar River and Bear Creek, there was very little difference in flow levels and timing between the two years (**Figure 8**). Consequently, we do not attribute the differences in egg to migrant survival that we measured between the two years in the Cedar River to flow. We have yet to examine the flow data for Bear Creek but overall egg to migrant survival in this stream was unchanged between the two broods.

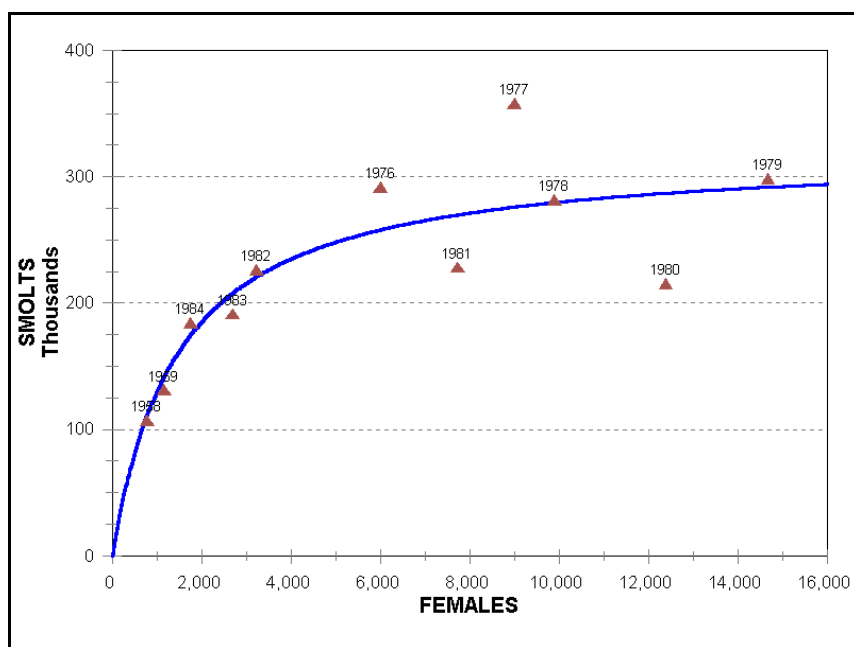


Figure 9 Spawner recruit relationship measured for wild coho salmon at the South Fork Skykomish River, brood years 1976-1984.

As flow variation between the two years does not explain the differences in egg to migrant survival, or differences in the proportions of fry and smolts produced, it is likely that the variation in spawner abundance is responsible. As **Figure 9** demonstrates for coho salmon, freshwater production is a positive function of spawner abundance.

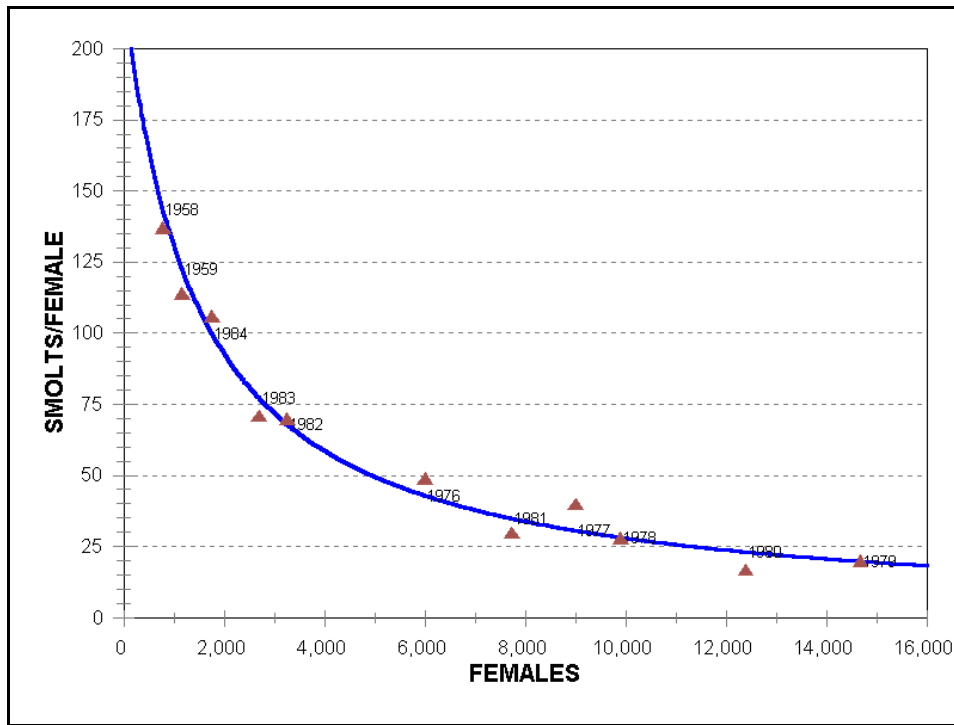


Figure 10 Productivity as a function of spawner abundance, South Fork Skykomish River wild coho, brood years 1976-1984.

Production per spawner, however, is a negative function of spawner abundance (**Figure 10**). As carrying capacity is approached, the incremental change in production per spawner declines. The outcomes we measured in both Bear Creek and the Cedar River over these two years are consistent with this scenario. The 1999 spawning population in Bear Creek, which produced the juvenile out-migration in year 2000, nearly doubled the number of spawners in 1998. While the overall survival-to-migration was identical between the two broods, smolt production per female spawner in the second brood declined somewhat, with increased fry production making up the difference. In the Cedar River, spawner abundance declined on the second brood, almost by half, and smolt production per female increased threefold. Fry production per female also increased in the second brood. An additional factor that may have contributed to the lower survival in the Cedar River, measured in 1999, was the dredging project conducted in Summer 1998. As a result, substantial head-cutting occurred in the lower Cedar River during Fall 1998. Any chinook redds in this affected zone would have been lost.

While it is too early in our evaluation of these two populations to fully understand the importance of the various factors that affect chinook production in freshwater, our results are consistent with the considerable differences that exist between the stream environments and habitat configurations of these two systems. For example, while the higher gradient Cedar River has an abundance of spawning habitat, it has a limited quantity of slackwater rearing habitat. Consequently, a high proportion of the chinook fry emerging from the gravel in this system probably are displaced downstream fairly rapidly. In contrast, Bear Creek is a lower gradient system with an abundance of slackwater rearing habitat replete with woody debris and streamside vegetation. Fry emerging from the gravels of Bear Creek find an abundance of rearing habitats. Of course, other species also inhabit these high quality but confined rearing reaches. Coho salmon and cutthroat trout are not only abundant residents throughout Bear Creek, but because of their larger size, comprise a

substantial predation pressure on chinook and sockeye fry. In 1999, for example we estimated that Bear Creek produced 64,000 coho smolts, 3,400 cutthroat migrants, and 1,800 two-year old steelhead smolts.

We currently attribute the differences in fry and smolt migration patterns and survival rates that we have measured in these two systems to the differences in habitat and resultant levels of species interaction. Continued monitoring of adult escapement and juvenile production will test these ideas, and thereby improve our understanding of how chinook salmon abundance is regulated in the freshwater environment.

Acknowledgments

King County has provided funding support for this project since 1992. A number of WDFW biologists have contributed to this project over the years: Greg Volkhardt, Lori Kishimoto, and Laurie Peterson have compiled and analyzed the data and produced reports; Pete Topping and Mike Ackley have constructed and installed traps and solved logistical problems; and Scientific Technicians Paul Lorenz, Dan Estell, Tim Eichler, John Thompson, and Jill Rossman spent long hours maintaining the traps and enumerating catches. At the Cedar River, the Renton Parks Department and the Renton Municipal Airport have provided access and a measure of security. The Boeing Company has graciously provided electrical power, enabling safer nighttime trapping. Likewise, at Bear Creek, Blockbuster Video has graciously provided electricity. The City of Redmond has welcomed this project from the outset, and the regular visits by the Redmond Police Department are much appreciated.